NASA Joint Confidence Level (JCL)

The Evolution of NASA's Cost Estimating Policy

2010 Department of Energy (DOE)
Cost Analysis and Training Symposium

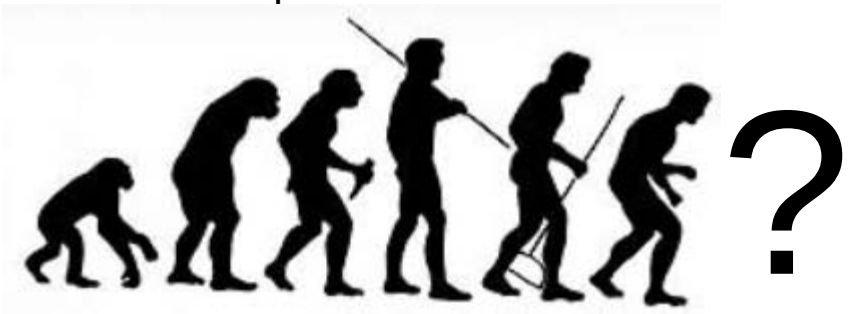
May 20, 2010

Statement of Purpose

- This presentation will address the evolution of the NASA cost estimating practice over the last several years
  - Discuss the underlining causality for NASA's specific implementation
  - Address fundamental issues facing the cost estimating community as well as the reasoning behind recent cost-related policy decisions
- It is important to note that the purpose of this presentation is not to advocate or educate on the latest NASA cost initiatives such as the Joint Confidence Level (JCL) policy, but rather to address the reasoning of these initiatives
- The authors hope this presentation will facilitate dialog between the NASA and DOE cost estimating communities with regards to common cost estimating/management issues and possible solutions

Quick History of Cost Estimating at NASA

- 1960s
  - Estimated by analogies, intuition and guesses; start of parametric estimating
- 1970s
  - Begin to collect historical data through databases; emergence of PRICE model
- 1980s
  - Complexity of NASA projects steadily increasing resulting in cost overruns despite better databases, better models, and better estimators (e.g. ISS and Shuttle Ops)
- 1990s
  - Government wide pressure to reduce the number of individuals working in job series like procurement, human resources, and budget
- 2000s
  - The focus of this presentation and to be addressed in the remainder of this presentation…



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Cost and Schedule Growth (2000's)

- The effects of the reductions in the 90's were felt when several Government Accountability Office (GAO) reports were critical of NASA's inability to complete projects within approved budgets
- Nearly all NASA projects sustain cost and schedule overruns
  - Generally all stakeholders are motivated to be optimistic, yet poor performance is typically blamed on poor cost and schedule estimates
  - Internal stakeholders most frequently blame external impacts
  - Not everyone understands these root causes nor is there consensus on what to do about it
  - The average cost growth rate over the past ten years has been 30-45% and projects have exceed their estimated launch dates by an average of about 35%
- NASA brought forth many initiatives to address GAO's concerns; Initiatives have been led by the HQ's Cost Analysis Division

Cost Analysis Division (CAD) Overview

In 2003, a dedicated office, Cost Analysis Division, was re-established to address Agency's cost issues through multiple initiatives:

- **Data and Databases**
  - Cost Analysis Data Requirement (CADRe)
  - One NASA Cost Engineering (ONCE) database
  - REsource Data STorage And Retrieval database system (REDSTAR)
  - Facilities and Ground Support Equipment Project Cost and Schedule Data Collection
- **Methodologies and Tools (Research)**
  - Sponsoring and updating in-house models
  - NASA Air Force Cost Model (NAFCOM)
  - NASA Instrument Cost Model (NICM)
  - Provide COTS cost and schedule tools (e.g., PRICE, SEER)
- **Community of Practice**
  - NASA Cost Estimating Handbook
    - Volume 1: Cost Estimating
    - Volume 2: Cost Risk
    - Volume 3: Economic & Supporting Analysis
    - Volume 4: NASA Cost Estimator Career Development Guide
    - Volume 5: Knowledge Management
  - NASA Cost Symposium / Executive Cost and Schedule Analysis Steering Group
- **Decisional Support and Policy**
  - Addressed in the remainder of this presentation…

Decisional Support and Policy

- Form follows function: Need to fully explain root causes and develop policy recommendations

If we want projects to meet cost and schedule commitments, we must budget and fund them with a higher probability of success

Documented Reasons for Cost Growth

	Cost Growth Reasons	1970s	1980s	1990s	2000s
	Inadequate definitions prior to agency budget decision and to external commitments	X	X	X	X
☑	Optimistic Cost Estimates/Estimating Errors	X	X	X	X
	Inability to execute initial schedule baseline	X	X	X	X
☑	Inadequate risk assessments	X	X	X	X
	Higher technical complexity of projects than anticipated	X	X	X	X
	Changes in Scope (Design/Content)	X	X	X	X
	Inadequate assessment of impacts of schedule changes on cost		X	X	X
	Annual Funding instability			X	X
	Eroding in-house technical expertise			X	X
	Poor tracking of contractor requirements against plans			X	X
	Launch Vehicle			X	
	Reserve Position adequacy		X		X
☑	Lack of Probabilistic estimating		X		X
	"Go as you can afford" Approach				X
☑	Lack of formal document for recording key technical, schedule and programmatic assumptions (CARD)**				X

** CADRe has since been implemented as a requirement of NPR 7120.5

☑ **Areas the cost community can address**

Sources:
GAO Report: Need for improved reporting & Cost Estimating on Major Unmanned satellite projects (NASA)
GAO Report: Financial Status of Major Federal Acquisitions
GAO Report to Congress March 1973 Cost Growth in Major Weapons Systems
Rand Report: Acquisition Policy Effectiveness October 1979
An Analysis of DOD/NASA Cost Growth Profiles for the Congressional Committee of Gov't operations January 1980
NASA Project Management Study January 1981
Office of Comptroller: New Project Estimates Study August 1985
Office of Comptroller: Lessons Learned on Cost/Schedule June 1990
NASA Program/Project Planning Study November 1992
NASA Cost Growth: A look at recent performance January 2004
GAO Work on DOD Space Acquisitions Dec 2006
GAO Report: NASA: Long Term Commitment to and Investment in Space Exploration July 2006
GAO Report: NASA: Lack of Disciplined Cost-Estimating Processes Hinders Effective Program Management May 2004

Why We Do Probabilistic Cost Estimating

Fact: It is impossible to estimate precisely how much something will cost or how long it will take

- Decision-makers and cost analysts should always think of a cost estimate as a probability distribution, NOT as a deterministic number
- The best we can provide to decision-makers is the cost probability distribution
- It is up to the decision-maker to decide where (i.e., at which confidence level) he/she wants to set the budget
- The probability distribution provides a quantitative basis for making this determination

Initial Probabilistic Cost Estimating Policy

- Probabilistic estimating guidance was first mentioned in February 2006 in an email from the NASA Administrator directing NASA's largest program, Constellation, to budget to a 65% confidence level
- Discussed again a month later at a strategic management meeting in March 2006
  - "Griffin determined that NASA's standard practices will be to budget projects at a 70% confidence level based on the independent cost estimate. Any proposed deviations from this standard must be brought forward for consideration to the appropriate management council."
  - "… initiate a pattern of honest dealing between Program and Project Managers, HQ, the Congress, and the WH, and to avoid the pattern of finger-pointing for cost overruns and schedule slips that have plagued the industry in the past".
- Clarified guidance a year later in March/April 2007
  - NASA flight system projects must submit budgets at a 70% confidence level starting at conception
  - Budgets based on a reconciliation between the project manager's estimate and an independent probabilistic cost estimate
  - An independent organization within the Office of the Administrator completes the independent probabilistic cost estimate during a non-advocacy review for high-level missions; otherwise the operating organization is responsible for obtaining an independent estimate
  - 70% Confidence Level budgets not required for projects in operation where budgets are funded at level of effort

Initial Policy Lessons Learned

- Benefits
  - Forced cost community to do probabilistic analysis*
  - The NASA cost community was already engaged in developing tools and methodologies that supported
  - Redirected dialog with external stakeholders away from “reserves” discussion
  - More transparent with stakeholders on expectations and probabilities of meeting expectations

- Issues
  - Lack of formally documented policy guidance
  - Not captured in policy directives or procedural requirements (NASA governance structure)
  - Lack of schedule risk in the confidence statement
  - Project versus independent review team reconciliation/timeline

* There were pockets of estimators doing probabilistic analysis way before 2006 guidance

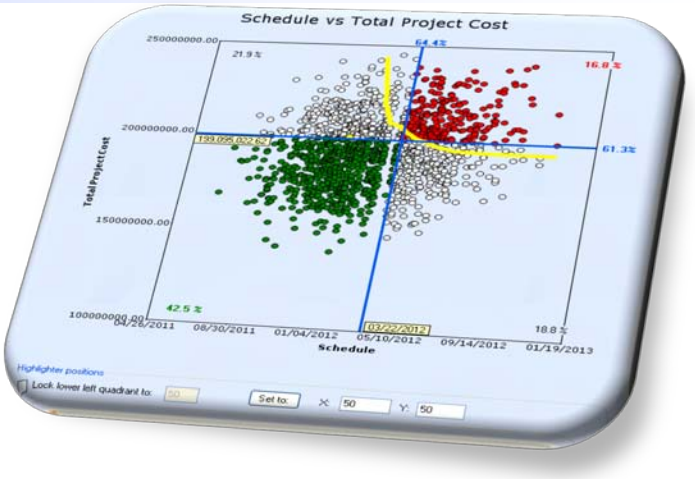
A Successive Generation of Probabilistic Policy
The Dawn of Joint Confidence Level

- In January 2009, NASA's cost estimating policy was updated to reflect lessons learned from the past few years
  - Programs to be baselined at a 70% joint confidence level (a 70% probability the program's projects will be completed at or below the estimated cost & at or before the projected schedule).
  - Projects to be baselined/budgeted at JCL that supports the program approved JCL
  - Projects to be funded at no less than a 50% JCL or as approved by the decision authority
  - JCLs to be developed and maintained through lifecycle beginning at implementation
  - Programs in extended operations generally not required to develop JCL, but new or upgraded capabilities within ops will develop JCL
  - Program and project proposed cost and schedule baselines will be assessed by an independent review team
  - External commitments will be based on JCL approved by the responsible Agency management council
  - Programs and projects are annually reviewed to confirm that current baselines and JCL are consistent with their annual budget submit. Significant changes to funding are to be reviewed and approved by the responsible Agency management council

Source: NPD 1000.5

What is JCL?

- JCL = Joint Confidence Level
  - Identifies probability that a given project or program's cost will be equal or less then the targeted cost AND the schedule will be equal or less then the targeted schedule date



- JCL is More than the Scatter Plot
  - Improves project planning by systematically integrating cost, schedule, and risk products and processes
  - Facilitates transparency with stakeholders on expectations and probabilities of meeting those expectations
  - Provides a cohesive and holistic picture of the project ability to achieve cost and schedule goals and to help the determination of reserves (schedule and cost)
- Provides key decision support information
  - Does the project have enough funds?
  - Can the project meet the schedule?
  - What are areas of risk toward successful execution of the project?
  - What risk mitigation strategies provide the best project benefit?
  - What are project phasing (fund) needs?

JCL Lessons Learned - Benefits

- Improves project planning by integrating cost, schedule, and risk products and processes
- Focuses on the inputs to project plans instead of the outputs
  - NASA management resonates with the discussion of specific technical and programmatic inputs
  - Facilitates better communication between the project and the independent review team
- Complements many of the Agency's existing systems and activities (e.g., Earned Value Management)
- Reserve levels are not dictated by standards or rules of thumb, but derived from the project's unique technical and programmatic characteristics (treated as unfunded future expenses)
  - Facilitates better understanding and communication of project health to external stakeholders
- Incorporates schedule into the confidence level calculation
  - Genesis of Joint Cost and Schedule Confidence Level (JCL)
  - Forces project to address and understand time independent and time dependent costs
  - Enforces scheduling best practices (i.e., schedule health checks)
- Strengthens risk management
  - Quantifies risks in terms of cost and schedule impacts
  - Addresses risk realization instead of only risk mitigation

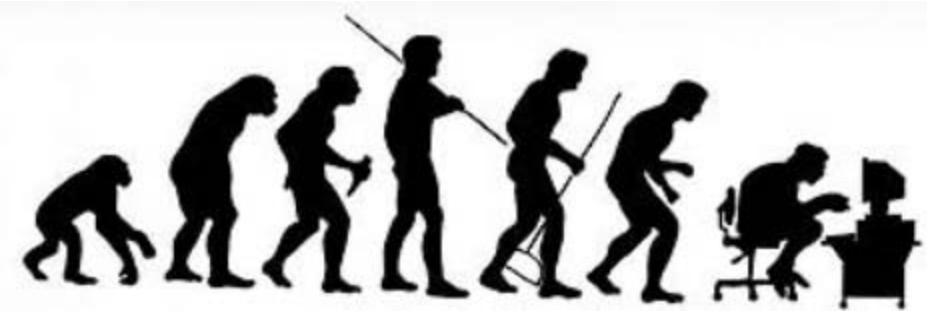
Testimony: Despite its many shortcomings, a JCL developed by the project and reviewed by the [independent review team] is probably the best known way to methodically establish a reasonably-conservative justifiable cost/schedule estimate that has the support of both the project and independent reviewers

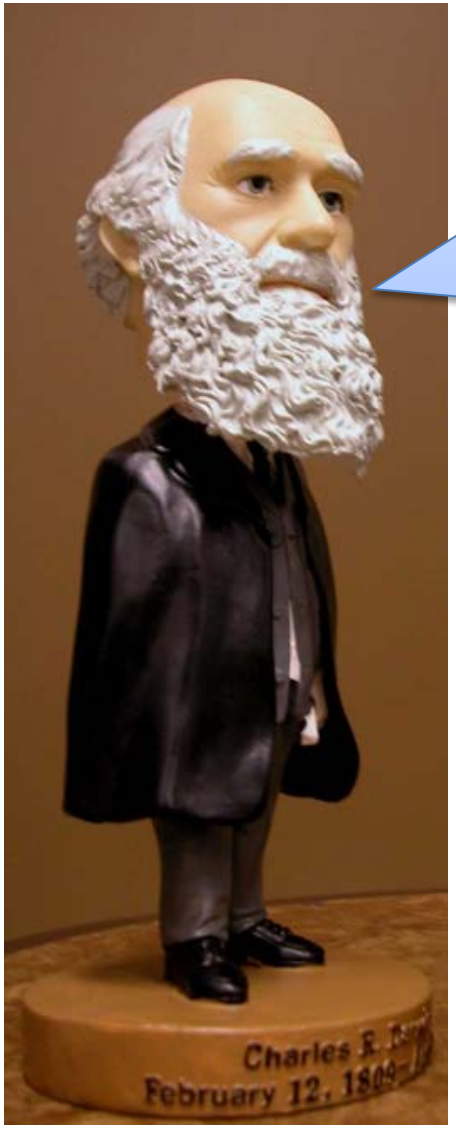
JCL Lessons Learned - Issues

- Most projects do not appear to know how to develop JCLs (parametrically or via resource-loaded schedules)
  - CAD has invested much time and consulting assistance for NASA projects
- Projects still somewhat confused about the need to reconcile their plans with other “independent estimates”
- Projects have most of the component parts -- just not integrated
  - Risk lists do not appear to contain all the risks that can impact project cost or schedules
    - Risk systems appear to disincentivize identification of all risks because mitigation plans are required
    - Project Manager’s sometimes elect to identify only items that they can mitigate
  - Project schedules are at a much lower level of detail than available cost data (hard to “resource-load” schedules)
- JCL calculations are pushing the limits of current available toolsets
- The development of higher level “manageable” schedules is the most time consuming step
- Difficulty with splitting fixed vs. variable costs (time-dependent/time independent)
- Projects are typically unfamiliar with probabilistic tools (although many already use Microsoft Project for their schedules)
- Difficulty in understanding and modeling unknown-unknown risks (uncertainty)
- Level of fidelity and syntax between traditional cost and schedule communities are fundamentally different – current policy makes these two communities co-exist and cooperate
- Confusion lingers on how the JCL relates to the issue of “contingency” or “reserves”
- “True” JCL is not possible for a loosely coupled Program
- Programmatic constraints leading to implementation

Continuing to Evolve

- "Survival of the fittest" approach
  - Natural selection of community "best practices" are emerging from analysis with regards to fidelity, techniques, tools, and methodologies
- Cost and schedule community are actively engaged in honing the current policy to reflect recent experiences
  - JCL analysis will be performed earlier in the lifecycle (during early formulation)
  - Basis of Estimate reviews will be conducted for projects entering formulation
  - Program JCL language will be dropped
- CAD is actively working "best practices" JCL handbook
  - Improve JCL models and calculations
  - Make the resulting JCL model "maintainable"
  - Incorporate performance metrics into the JCL calculation





Any Questions?

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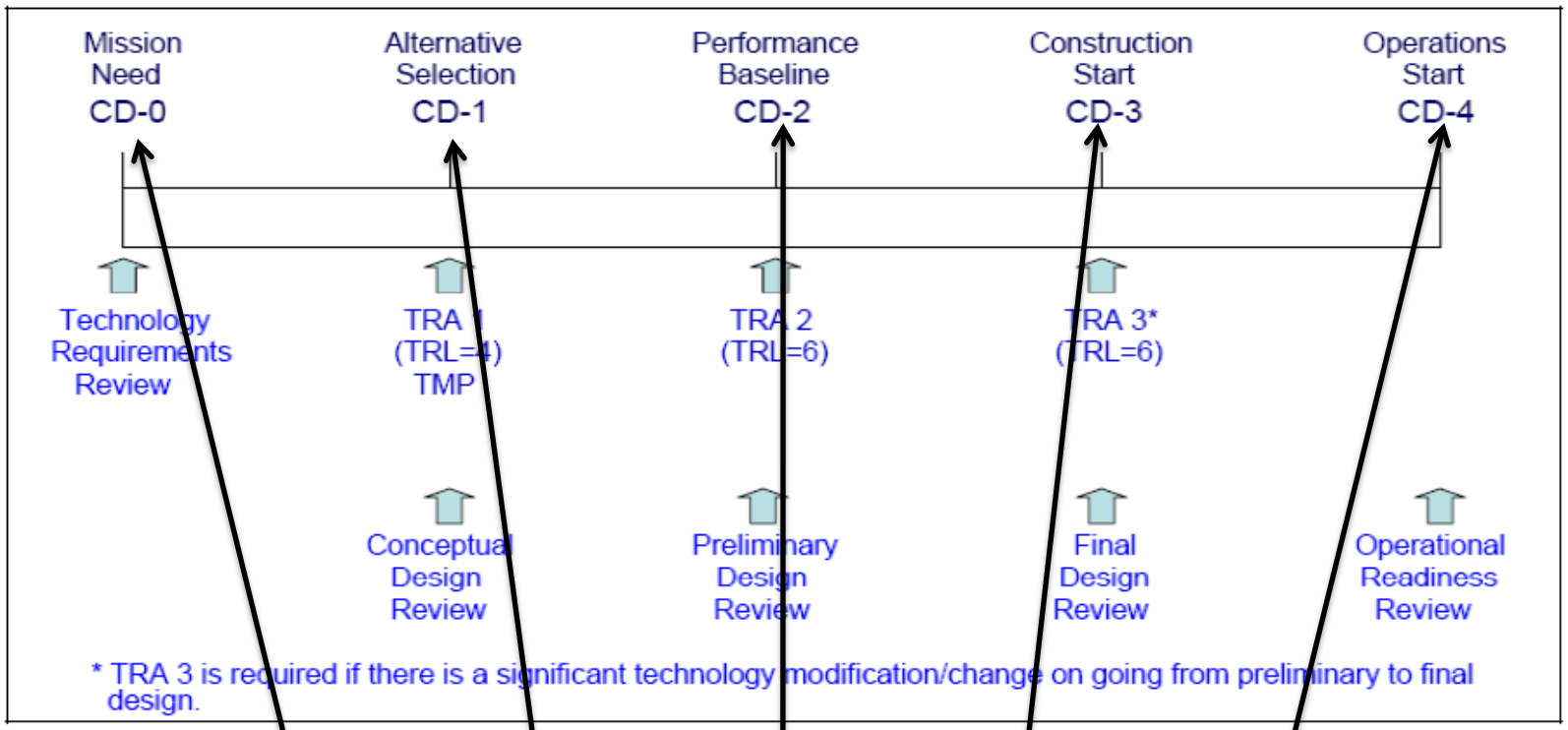
DOE and NASA Milestones/Reviews Crosswalk



NASA

NASA Life Cycle Phases	FORMULATION		Approval for Implementation	IMPLEMENTATION			
	Pre-Systems Acquisition			*Systems Acquisition*	*Operations*	*Decommissioning*	
Project Life Cycle Phases	Pre-Phase A: Concept Studies	Phase A: Concept & Technology Development	Phase B: Preliminary Design & Technology Completion	Phase C: Final Design & Fabrication	Phase D: System Assembly, Int & Test, Launch	Phase E: Operations & Sustainment	Phase F: Closeout
Project Life Cycle Gates & Major Events	KDP A, FAD, Draft Project Requirements	KDP B, Preliminary Project Plan	KDP C, Baseline Project Plan?	KDP D	KDP E, Launch	KDP F, End of Mission	Final Archival of Data

Source: NPR 7120.5

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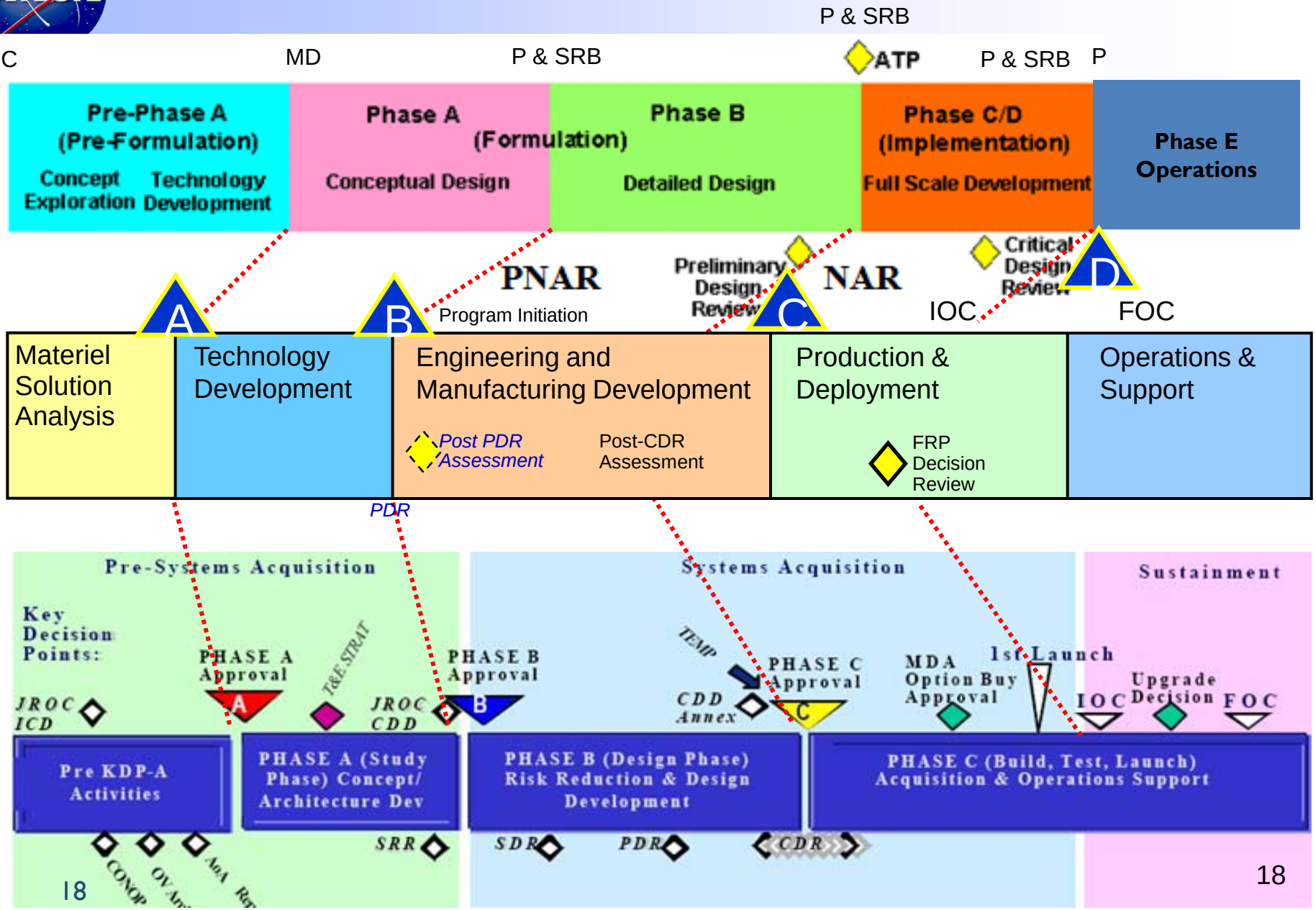
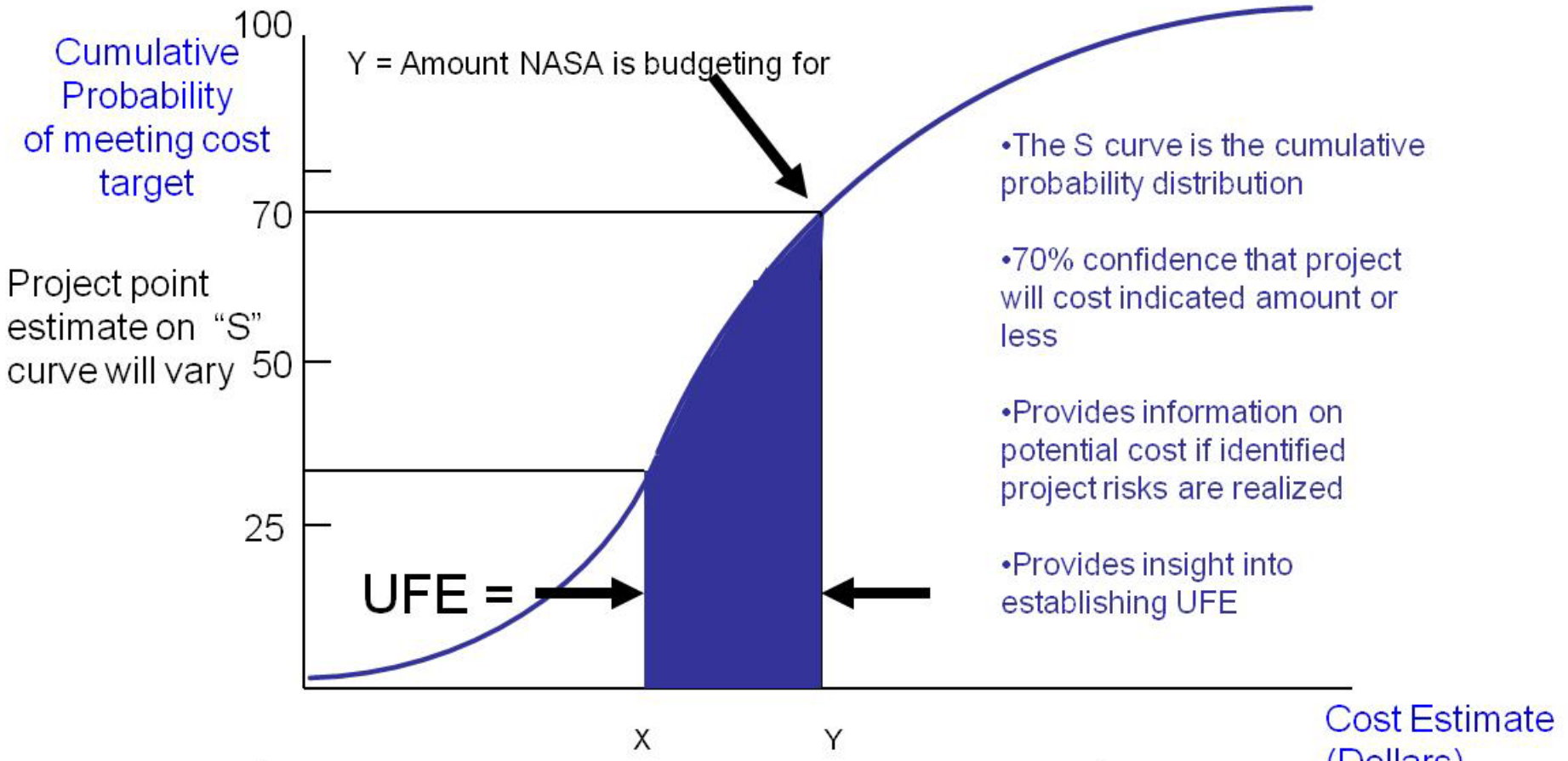


Unfunded Future Expenses (UFE)

X = Project's Deterministic (Point) Estimate*
Y = Cost estimate where there is a 70% chance that final actual cost will be less than project cost estimate
UFE = Y-X= Management reserve



UFE is REQUIRED to meet the objectives of the project.
Reducing the UFE lowers probability of project success